DESCRIPTION

OF THE

UNIVERSAL EQUATOREAL,

AND OF THE

NEW REFRACTION APPARATUS,

Much Improved by Mr. RAMSDEN,

WITH THE

METHOD of adjusting the INSTRUMENT for OBSERVATION.

AS ALSO

INSTRUCTIONS for making OBSERVATIONS with it.

Ramsden

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DESCRIPTION

Of the Univerſal Equatoreal, made by Mr. Ramsden, *with the Method of adjuſting it for Obſervation.*

THE principal Parts of it are: *(See Print of the Equatoreal.)*

Iſt. The Azimuth or Horizontal Circle (A) (repreſenting the Horizon of the Place) which moves on a long Axis (B) called the Vertical Axis.

IId. The Equatoreal or Hour Circle (C) repreſenting the Equator placed at right Angles *to*, and moving *upon* the *Polar Axis* (D) which repreſents the Axis of the Earth.

IIId. The Semi-Circle of Declination (E) (on which the Teleſcope is placed) moves on what is called the Axis of Declination, or, *the Axis of Motion of the Line of Collimation* (F).

IVth. Meaſures of the ſeveral Circles and Diviſions of them.	Radius In dec.	Limb divided to	Vernier of 30 gives	Divided on limb to parts of In.	Divided by Vernier to parts of In.
Azimuth or Horizontal Circle, -	5 - 1 2 - 7	15′ 30′	- 30″ - 1′ - - -	- 45th. - - 42d. -	1350th. 1260.
Equatoreal or Hour Circle, - -	5 - 1 2 - 7	15′ 1′ time 30′ 2′ time	- 30″ - - 2″ - 1′ - - - - - 4″ -	- 45th. - - 42d. -	1350th. 1260.
Vertical Semi-Circle for Declination or Latitude,	5 - 5 2 - 75	15′ 30′	- 30″ - 1′ - - -	- 42d. - 41	1260th. 1230.

Note—The ſecond Line in each Diviſion of the above Table gives the Meaſures of the ſmaller-ſized Equatoreals.

Vth. The

Vth. The Telescope is an Achromatick Refractor with a triple Object Glass, the Focal Distance whereof is 17 Inches and its Aperture : $\overset{\text{In}}{2}\overset{\text{Dec.}}{,45}$. and there being five different Eye-Tubes, and one Prismatic Eye-Tube, its Magnifying powers run from 49 to 168. By a new Contrivance in this Equatoreal, the Telescope may be brought parallel to the Polar Axis, so as to point on the Pole-Star in whatever part of its apparent diurnal revolution it be, and with this Telescope it has been seen near 12 o'clock at noon, and the sun shining very bright.

VIth. The Refraction Apparatus (for correcting the error in altitude caused by Refraction or by Parallax) goes on upon the Eye-End of the Telescope, it contains a set of Moveable Wires, and may be turned quite round by its Pinion—the Description of this Refraction Apparatus shall be given hereafter.

VIIth. This Instrument stands on three feet (L) distant from each other, $\overset{\text{In}}{14}\overset{\text{Dec.}}{,4}$.

VIIIth. When all the parts are horizontal, it is about 29 inches high.

Before you proceed to adjust this Instrument, consider well the several parts of it, and you will see, that the principal adjustment thereof (to which every other adjustment must tend) is to make the *Line of Collimation* (that is, the Line of Vision cut by the intersecting point of the *fixed* Wires in the Telescope) describe a portion of an *Hour Circle* in the Heavens — in order to *that*, it is plain that several previous adjustments must be made; such as, that the Azimuth Circle must be truly

truly level—that the *Line of Collimation* (or ſome Subſtitute thereof, entirely correſpondent to it) muſt be at right Angles to the Axis of *its own proper motion*, that is, the Axis of the Declination Circle (F) and that this laſt Axis muſt be at right Angles to the Polar Axis, or Axis of the Earth; the Polar Axis by the conſtruction of the Equatoreal (without any adjuſtment) is at right Angles to the Equatoreal Circle.——There is a ſmall Braſs Rod (M) placed immediately under the Teleſcope, which is meant to be parallel *to*, and the ſubſtitute *of*, the Line of Collimation, and (as above mentioned) is entirely correſpondent to it, and to be conſidered as one and the ſame thing with it, in going through the 2d. 3d. 4th. Adjuſtments—On this braſs rod there is occaſionally placed a hanging level, (N) the many advantages of which in various operations, the following Adjuſtments will clearly ſhow.

Level the Azimuth Circle.

1ſt. ADJUSTMENT.

Turn it, till one of the Levels is parallel to a ſuppoſed line joyning two of the feet ſcrews, then adjuſt that Level with thoſe two feet ſcrews; turn the Circle half round, *i. e.* 180°, and if the bubble be not then right, correct half the error by the ſcrew belonging to the Level, * and the other half error by the aforeſaid two feet ſcrews; repeat this till the

* Obſerve when the point of any Screw is *tap'd* into the ſurface it preſſes upon, then by *ſcrewing* you *depreſs* and by *unſcrewing* you *elevate* that part, but when the point of the Screw is *not tap'd* into the ſaid ſurface (as the Feet Screws of the Equatoreal) then *ſcrewing elevates*, and *unſcrewing depreſſes.*

the bubble comes right — then turn the Circle 90°. *from* (that is, at right angles *to*) the two former positions, and set the bubble right (if it be wrong) by the foot screw at the end of the Level; that done, adjust the other Level by its own screw, and the Azimuth Circle will then be truly Level.

2d. ADJUSTMENT. *Make the two Hooks of the Hanging Level equal in length; so that the Level may be truly parallel to the Brass Rod on which it is suspended.*

Hang on the Level, and adjust it by the Pinion of the declination Semi-Circle; reverse the Level, and if it be wrong, correct half the error by a small steel screw that lies under one end of the Level, and the other half error by the Pinion of the declination Semi-Circle; repeat this till the bubble be right in both positions.

3d. ADJUSTMENT. *Make the Brass Rod on which the Level hangs, at right Angles to the Axis of Declination* (F).

Make the Polar Axis Horizontal, or nearly so; set the declination Semi-Circle to 0°., turn the Hour-Circle till the bubble comes right; then turn the Declination-Circle to 90°.; adjust the bubble by raising or depressing the Polar Axis (first by hand till it be nearly right, afterwards to make it entirely right, tighten with the Ivory Key the socket which runs on the Arch with the Polar Axis, and then apply the same Ivory Key to the adjusting screw at the

the end of the ſaid Arch till the bubble comes quite right) then turn the Declination-Circle to the oppoſite 90°, if the Level be not then right, correct half the error by the aforeſaid adjuſting ſcrew at the end of the Arch, and the other half error by the *two ſcrews* which raiſe or depreſs the end of the *braſs rod.*——N· B. theſe ſcrews preſs againſt each other, ſo you muſt unſcrew the one, before you ſcrew the other.

Make the Axis of Declination at right Angles to the Polar Axis. 4th. ADJUSTMENT.

Set the Polar Axis Horizontal, or nearly ſo, and the declination Semi-Circle to 0° adjuſt the bubble, by the Hour-Circle, then turn the declination Semi-Circle to 90° and adjuſt the bubble by raiſing or depreſſing the Polar Axis; then turn the Hour-Circle 12 Hours, and if the bubble be wrong, correct half the error by the Polar Axis, and the other half error by the two pair of capſton ſcrews, at the feet of the ſupports, of the *Axis of* Declination.

REMARK.

By the three laſt adjuſtments you have brought the Level to be truly parallel to the braſs rod and the ſaid *braſs rod* (or, line of collimation, which for the preſent is to be conſidered as the ſame thing) to be at right angles to the Axis of Declination, and this laſt Axis to be at right angles to the Polar Axis.

Fifth

5th. ADJUSTMENT. *Make the Centres of the Moveable and of the Fixed Wires coincide, while you turn the Eye-Tube quite round by the Pinion of the Refraction Apparatus.*

Turn the Eye-Tube till the Horizontal *Moveable* Wire is perfectly Horizontal, and if it does not cover the Horizontal *Fixed* Wire, set it to it by means of the small Refraction Circle—Invert the Horizontal *Moveable* Wire (by turning the Eye-Tube half round) and if it does not then cover the Horizontal *Fixed* Wire, correct half the error by the uppermost and lowermost of the four small Screws in the Eye-piece, which adjust the *Fixed* Wires, and the other half error by the aforesaid small Refraction Circle — repeat this till the Horizontal *Moveable* Wire covers the Horizontal *Fixed* Wire when turned to either Position — then set the Index of the small Refraction Circle to its Zero— and turn the Eye-Tube till the Horizontal *Moveable* Wire becomes Vertical—Adjust the Vertical *Fixed* Wire by its two Horizontal Screws, and adjust the Horizontal *Moveable* Wire by a small screw on the part that contains the *Moveable* Wires—the Centres of the *Moveable* and of the *Fixed* Wires will then coincide during an entire Revolution of the Eye-Tube.

6th. ADJUSTMENT. *Make the Line of Collimation parallel to the Brass Rod on which the Level hangs.*

Set the Polar Axis Horizontal, the Hour Circle to six Hours, and the Declination Circle to 90° — Adjust the

the Level by the Polar Axis — look through the Telescope on some distant Horizontal Line covered by the Wire — then invert the Telescope (this is done by turning the Hour Circle half round, or 12 hours) and if the Horizontal Wire (the Level being adjusted) does not cover the same Horizontal Line, correct half the error by the *uppermost* and *lowermost* of the four small Screws at the Eye-End of the large Tube of the Telescope— this correction will give you a second Horizontal Line now covered by the Horizontal Wire which you will adopt instead of the first Line—Invert the Telescope as before, and if the second Horizontal Line be not covered by the Horizontal Wire, correct half the error by the same two Screws (the *uppermost* and *lowermost*) you used before— repeat this operation till the Wire covers the same Horizontal Line in both positions—then set the Hour Circle to 12 Hours, and adjust the Level by the Pinion of the Declination Circle, and by means of the two remaining small Screws make the Vertical Wire (now become Horizontal) cover a Horizontal Line, exactly as much higher than your former Horizontal Line, as the Line of Collimation (or Centre of the Telescope) is now above the Centre of the Polar Axis, and the Line of Collimation will then be parallel to the Brass Rod.

7th. ADJUSTMENT. *Rectify the Verniers of the Declination and of the Equatoreal Circles.*

Elevate the Equatoreal Circle to the Co-Latitude of the place, * and set it to six hours; adjust the Level by the Pinion of the Declination-Circle; then turn the Equatoreal Circle *exactly 12 hours* from the *last position*; and if the Level be not right, correct one half of the error by the Equatoreal Circle; and the other half by the Declination Circle; then turn the Equatoreal Circle back again, exactly 12 hours from the last position, and if the Level be still wrong, repeat the correction as before, till it be right when turned to either position; that being done, set the Vernier of the Equatoreal Circle exactly to six hours, and the Vernier of the Declination Circle, exactly to 0°.

* Thus—lower the Telescope as many Degrees, Minutes and Seconds below 0° (or Æ) on the Declination Semi-Circle, as the complement of your Latitude is; then elevate the Polar Axis till the bubble be Horizontal, and the Equatoreal-Circle will be elevated to the Co-Latitude of the Place, as required.

Method

Method of Adjusting the Smaller-sized Equatoreal.

Make the two Hooks of the Hanging Level equal in length; so that the Level may be truly Parallel to the Brass Rod on which it is suspended. 1st. ADJUSTMENT.

This is precisely the same with the Second Adjustment of the Large Equatoreal.

Make the Centres of the Moveable and of the Fixed Wires coincide, while you turn the Eye-Tube quite round by the Pinion of the Refraction Apparatus. 2d. ADJUSTMENT.

This is the same with the Fifth Adjustment of the Large Equatoreal.

Make the Line of Collimation parallel to the Brass Rod on which the Level hangs. 3d. ADJUSTMENT.

Set the Polar Axis Horizontal, the Hour Circle to Six Hours, and the Declination Circle to 90°. Adjust the Level by the Polar Axis—look through the Telescope on some distant Horizontal Line covered by the Wire—then Invert the Telescope (this is done by turning the Hour Circle half round, or 12 hours) and if the Horizontal Wire (the Level being Adjusted) does not cover the same Horizontal Line, correct half the Error by the Polar Axis, and Adjust the Level by the two Screws which raise or depress the End of the Brass Rod; this Correction will give you a second Horizontal Line now covered by the Horizontal Wire, which you will adopt instead of the first Line. Invert the Telescope as before, and if the second Horizontal Line be not covered by the Horizontal Wire, repeat the same correction as above, till the Wire covers the same Horizontal Line in both positions—then set

ſet the Hour Circle to 12 hours, turn the Declination Circle till you make the Vertical Wire (now become Horizontal) cover a Horizontal Line, exactly as much higher than your former Horizontal Line, as the Line of Collimation (or Centre of the Teleſcope) is now above the Centre of the Polar Axis, and Adjuſt the Level by the Capſton Screw under the End of the Braſs Rod—the Line of Collimation will then be parallel to the Braſs Rod.

4th. ADJUSTMENT. *Make the Braſs Rod on which the Level hangs at right Angles to the Axis of Declination.*

Make the Polar Axis Horizontal; ſet the Declination Circle to 0°—turn the Hour Circle till the Bubble comes right; then turn the Declination Circle to 90°; adjuſt the Level by the Polar Axis—then turn the Declination Circle to the oppoſite 90°, if the Level be wrong, correct half the Error by the Polar Axis, and the other half Error by the *two Screws* at the *Eye End of the large Tube of the Teleſcope* which raiſe or depreſs that End.

5th. ADJUSTMENT. *Make the Axis of Declination at right Angles to the Polar Axis.*

The ſame as the Fourth Adjuſtment of the Large Equatoreal.

6th. ADJUSTMENT. *Level the Azimuth Circle.*

The ſame as the Firſt Adjuſtment of the Large Equatoreal.

7th. ADJUSTMENT. *Rectify the Verniers of the Declination and of the Equatoreal Circles.*

The ſame as the Seventh Adjuſtment of the Large Equatoreal.

Deſcription

Description of the New Refraction Apparatus much improved by Mr. Ramsden. Previous to the Perusal of which, let what follows be considered.

Refraction or Parallax, by changing the apparent Altitude of a Planet, may also change its apparent Right Ascension and Declination.—See Figure I.

Where H. O. Represents the Horizon.
E. Q. Part of the Equator.
P. Pole of the Equator.
Z. The Zenith.
P. E. H. The Meridian.
Z. V. An Arc of a Vertical drawn through I. the Apparent Place, and F. the true place of the Planet.
P. A. A Circle of Declination or Hour Circle drawn through the true Place F.
P. B. A Circle of Declination or Hour Circle drawn through the Apparent Place I.

The Error in Altitude from F. to I. alters the Right Ascension of the Planet as much as the Arc of the Equator A. B. (or its Parallel F. C.) amounts to. It also alters its Declination from A. F. to B. I.; that is, from C. to I. If a Planet be in the Meridian at L. the Error in Declination from L. to K. will be the same as the Error in Altitude; but there will be no Error in Right Ascension, because the same Circle of Declination P. E. H. (perpendicular to the Horizon) passes through the Apparent Place

K. and the true Place L. In like manner, if by the Construction of an Instrument you have a Vertical Circle Z. V. perpendicular to the Horizon, it will pass through the apparent Place I. and the true Place F. and there will be no Error in Right Ascension. And if by the same Instrument the Error in Altitude from F. to I. be determined, the true Place F. is found, and consequently there will be no Error in Declination.

With Mr. Ramsden's New Refraction Apparatus, you have such a Vertical Circle as will appear in what follows.

In the Focus of the Telescope of the Equatoreal, two *fixed* Wires are placed at Right Angles to each other; one, E. Q. (see Figure II.) represents part of a Parallel of the Equator, : the other, P. A. part of a Meridian, or Hour Circle. There are also two *moveable* Cross Wires at Right Angles to each other; one, H. O. represents a portion of a Parallel to the Horizon : the other, Z. V. a portion of a Vertical Circle. These moveable Wires have a motion round the Axis of the Telescope, by turning a Pinion. A small Quadrant, (I.) (see Print of the Equatoreal,) is fixed on the part that carries the moveable Wires, with Divisions on each Side; one expressing the Degree of Altitude of the Object viewed; the other expressing the Minutes and Seconds of Error occasioned by Refraction, corresponding to that Degree of Altitude. To the Index of this Quadrant is fixed a small Circular Level, (K.) which, being adjusted by its own Pinion, gives you the Altitude; while by another Pinion it ascertains the Perpendicularity of one

of

of the moveable Wires, which gives you the Vertical Circle abovementioned, whereby the true Right Aſcenſion may be determined, free from all Error, ariſing from Refraction or from Parallax. Hence, in taking the Moon's Right Aſcenſion with an Equatoreal, fitted with this Refraction Apparatus, in order to determine Longitudes at Land, there is no occaſion to attend to her Parallax, as the difference of her Right Aſcenſion cauſed by Parallax or Refraction, will only depreſs or elevate her on the ſame Vertical Circle, but will not change her Right Aſcenſion from one Hour Circle to another.

In this Refraction Apparatus, the Centre of the fixed Wires always remains in the Line of Collimation; whereas, by the former Conſtruction, on raiſing or depreſſing that Centre, it was moved out of that Line; and as it was very difficult to replace it again exactly, it was liable to produce an Error in the Obſervation.

☞ In all Obſervations made with this Refraction Apparatus, firſt Adjuſt the Circular Level, then ſet the Centre of the moveable Wires (by the Micrometer Screw) to the Refraction correſponding to the Altitude of the Object viewed, as given you by the ſmall Quadrant, and let one of the moveable Wires be always ſet perpendicular.

With

With this Refraction Apparatus you may also determine what the Errors in Altitude, and Right Ascension, caused by Refraction or Parallax, would be, with an Equatoreal NOT *fitted with this Refraction Piece: the Error will be greater in Right Ascension if you have* NOT *a Meridian fixed, than if you have one; though the Error in Altitude will, in both Cases, be the same.*

To explain this, see Figure III. where

P. A. Represents part of a Declination or Hour Circle.
C. I. Part of another Declination or Hour Circle.
E. Q. Part of a Parallel of the Equator.
Z. V. A Vertical.
H. O. A Parallel of the Horizon.
F. The Centre of the fixed Wires, or *true* place of the Object.
I. The Centre of the moveable Wires, or *apparent* place.

The Equatoreal and Declination Circles being properly set, suppose you want to find your Meridian, but without having a Refraction Piece—in that case you move the Azimuth and Hour Circles till you get the Centre of the fixed Wires to cover the apparent Centre of the Sun or a Star; whereby, from Refraction, there will be an Error in Altitude, which will cause an Error in Right Ascension, and consequently an Error in Azimuth: now, to determine the quantity of each of those Errors by making use of the Refraction Piece, proceed thus:

Set

Set the Refraction Piece to the quantity of Refraction correſponding to the Altitude of the Object; thus you have the Error in Altitude, which (in this Example) ſuppoſe F. I; then note the points at which the Azimuth and Equatoreal Circles ſtand: after that, move both thoſe Circles till you bring the Centre of the *moveable* Wires to cover the *apparent* Centre of the Sun or Star at I.; then its *true* Centre will be at F.: and the difference between the former and the preſent points at which thoſe two Circles now ſtand, gives you the Error in Right Aſcenſion F. D. and the conſequential Error in Azimuth D. I.

In the laſt caſe you had no Meridian fixed; but now ſuppoſe you have a Meridian, and you want to determine what the quantity of Error produced by Refraction in Altitude, and from thence in Right Aſcenſion, would be if you had no Refraction Piece.

As to the Error in Declination cauſed by Refraction, it may be found by the Declination Circle itſelf, without the aid of the Refraction Piece.

The Error in Altitude is given you by the Refraction Piece; and the Error in Right Aſcenſion ariſing from that in Altitude is thus found:

Suppoſe the Equatoreal to remain exactly right in all its parts, as it was left in the laſt Example, viz. the *true* Centre of the Sun or Star in the Centre of the fixed Wires at F.—the *apparent* Centre of the Sun or Star in the Centre of the moveable Wires at I.—the Errors corrected by the Refraction Piece—in Altitude from I. to F.—in Right Aſcenſion from C. to F. (which is the diſtance

meaſured on a Parallel of the Equator between Portions of the two Hour Circles A. P. and C. I.)—and the Error in Declination from I. to C.

Now (being without a Refraction Piece) you would of courſe move the Hour Circle till the Wire A. P. making a portion of an Hour Circle *cut* the *apparent* Centre of the Sun at I.* that movement gives you the Error in Right Aſcenſion from F. to C.—then you would move the Declination Circle from the true Declination at C. till the Centre of the fixed Wires covered the *apparent* Centre of the Sun at I.; the quantity you have then moved, is the Error in Declination from C. to I.—by theſe movements you will have brought the Centre of the fixed Wires at F. to I. (where the Centre of the moveable Wires was, when it covered the *apparent* Centre of the Sun); and the line from F. to I. is the Error in Altitude which the Refraction Piece gives you.

Or, to find the Errors in Declination and Right Aſcenſion at once, you might chooſe to move the Declination and Hour Circles together, till the Centre of the fixed Wires at F. is brought to cover the *apparent* Centre of the Sun at I.—the alterations of thoſe Circles will give you reſpectively the Errors wanted.

* Obſerve, that when the Declination Circle is tiuly ſet (as it is in this caſe), the Centre of the fixed Wires can never be brought to coincide with the apparent Centre of the Sun, but muſt be below it, owing to Refraction; therefore it is here directed to make the Wire (in one part or other of it) cut the Centre of the Sun.

It

It is judged proper, for the benefit of persons who have not been converſant in making Aſtronomical Obſervations, to ſtate here at large, all the Principal Obſervations to be made with this Equatoreal, and the Methods of Obſerving with it.

OBSERVATION I.

To find the Latitude of the Place by the Sun, or any known Fixed Star.

The Inſtrument being perfectly adjuſted in all its parts according to the Directions given——

Make the Polar Axis Perpendicular to the Horizon, and when the Sun approaches His Meridian Altitude, Elevate the Teleſcope to that Altitude, and adjuſt the Refraction Apparatus as above directed—then follow the Sun, by moving both the Equatoreal and Declination Circles (if neceſſary) and keeping the Refraction Piece always adjuſted till He is at His greateſt Altitude; the Vernier of the Declination Circle will then give you His Meridian Altitude; from which Subtract His Declination, if it be North, or, Add it, if it be South, the remainder, if North, and the Sum, if South, is the height of the Equator, that is the Complement of your Latitude—which being Subtracted from 90° Degrees, gives your Latitude.

EXAMPLE

EXAMPLE.

Sun's Declination, ſuppoſed .	6°. 57.′ 37″ North
Meridian Altitude of His Centre Obſerved	45°. 6.′ 29″
Subtract His Declination .	6. 57. 37
Height of the Equator or Co-Latitude .	38°. 8.′ 52″
which Subtracted from	90°.
gives your Latitude . . .	51°. 51.′ 8″

If inſtead of obſerving the Altitude of the Centre, you obſerve that of the Upper or Lower Limb of the Sun, you muſt allow for the Semidiameter of the Sun, which allowance you find in the Nautical Almanac.

OBSERVATION II.

To find the Meridian by ONE OBSERVATION ONLY.

Elevate the Equatoreal (or hour) Circle to the Co-Latitude of the Place, ſet the Declination Circle to the Sun's Declination for the Day and Hour required; and adjuſt the Refraction Apparatus, then move the Azimuth and Hour Circles both at the ſame time (either in the ſame, or in a contrary Direction) till you bring the Centre of the moveable Wires *(the vertical being truly perpendicular)* exactly to cover the *apparent* Centre of the Sun — that done, the Centre of the *fixed* Wires will be in the true Centre of the

the Sun ; the Index of the Hour Circle will then give the Apparent or Solar Time at the Instant of Observation: thus you get the time, though the Sun be at a distance from the Meridian. Then turn the Hour Circle till the Index points precisely at 12 o'Clock, and lower the Telescope to the Horizon, to observe some mark in the Centre of the Telescope; and that is your Meridian, found by *one Observation only.*

The best time for finding the Meridian is, when the Sun is three hours distant from the Meridian on either side of it.

Observe, that when you have once a true Meridian fixed, you need make no use of the Refraction Apparatus in any Observation, except to set one of the moveable Wires perpendicular.

NB. The Meridian and Solar time may be found in like manner by a fixed Star whose Declination and Right Ascension is known.

OBSERVATION III.

To observe a Star or Planet in Broad Day-light, at any Time when it is above the Horizon.

N. B. The Table of R^t^ Ascen^ns^, Declinations, &c. of 44 Principal fixed Stars, gives you the times of their Transits over the Meridian.

Elevate the Equatoreal Circle to the Co-Latitude of the Place, and set the *Vernier* of the Declination Circle to the Star's Declination, then Adjust the Refraction piece;

 look

look into the Table for the time of its Transit *immediately preceeding* your Observation; then take the Interval of time since *that* Transit to the time of your Observation as given by the Clock, and Add to it the Star's acceleration, corresponding to that Interval of time, this sum is the hour to which you must set the Hour Index of the Equatoreal Circle, and the Star will then appear in the Telescope.

The shortest way to get the Interval of time between the Star's Transit and the time of Observation, is, always to Subtract the time of the Transit from the time of Observation (adding 12 hours to the Clock if necessary) *only take care, not to mistake Morning Hours for Evening Hours*, or Vice Versâ.

EXAMPLE I.

Sept^r 30th, at 9 A. M. find Capella;	hours	
its Declination is —	45°. 44′. 29″	North.
its Transit (by the Table) is at - - -	H. 4. 22.′ 9.″	A. M.
which Subtract from time of Observation; viz.	- 9	A. M.
Remains Interval of time since its Transit . . .	4. 37. 51	
Add Acceleration for H. 4. 37.′ 51″	45″	
Set the Hour Index to	4. 38. 36	P. M.

EXAM-

EXAMPLE II.

May 31st at 2 P. M. find Arcturus;
its Declination is 20°. 22.′ 30.″ North.
its Transit (by the Table) that day is at 9. 25. 42. P. M. so that you must take its Transit for May 30th, because at 2 H. P. M. of May 31. it had not yet passed the Meridian that day

	H.	
—its Transit, May 30 is at	9. 29.′ 38.″	P. M.
which Subtract from the Time of Observation, viz. May 31, at	2.	P. M.
Remains Interval of time since its Transit . . .	4. 30. 22	

that is to say 16. H. 30.′ 22.″ since its Transit

Add Acceleration for 16. H. 30′ 22″	2. 42	
Set the Hour Index to . .	H. 4. 33.′ 4″	A. M.

OBSER-

OBSERVATION IV.

To find the Right Aſcenſion and Declination of a Planet, Comet or Fixed Star.

The Equatoreal Circle being Elevated as before to the Complement of the Latitude of the Place, move the Declination and Equatoreal Circles till the Planet or Comet is in, or near the Centre of the Field of the Teleſcope, then Adjuſt the Refraction piece, and bring the Centre of the moveable Wires to cover the Planet, the Vernier of the Declination Circle will then give you the Declination of the Planet, and the Vernier of the Equatoreal Circle will give you the hour of the Planet &c. — then your Regulator or Clock will give you the Sun's time or hour of the Day.—Take the Difference between the Sun's time and the Planet's time; and if the Planet's time be leſs than the Sun's time, add that Difference to the Sun's Right Aſcenſion at the time of Obſervation, (which you find in the Nautical Almanac) the Sum (rejecting 24 hours, if it exceeds that number) is the Right Aſcenſion of the Planet, &c. — Again; if the Planet's time exceeds the Sun's time, Subtract the difference from the Sun's Right Aſcenſion; the Remainder (adding 24 hours, to the Sun's Right Aſcenſion, if neceſſary) is the Right Aſcenſion of the Planet, &c.

EXAMPLE

EXAMPLE I.

	H.	′	″	
Obſerved a Star whoſe time by the Equat[l]. Circle is	2.	18.	3.	P. M.
Sun's time as given by the Regulator, viz.	9.	44.	40.	P. M.
Difference between the two	7.	26.	37.	
As the Star's time is leſs than the Sun's add that difference to Sun's R[t] Aſcenſion . . .	20.	57.	9.	
Reject 24 hours from .	28.	23.	46.	
Right Aſcenſion of the Star is	4.	23.	46.	

Its Declination (by the Vernier of the Declination Circle) is 16°. 2.′ 50.″ North.

EXAMPLE II.

	H.	′	″
Obſerved a Star whoſe time by the Equat[l] Circle is 10. A. M. (that is Aſtronomically) . .	22.	0.	0.
Sun's time as given by the Regulator viz. 5. 55. 4. A. M. (that is Aſtromically)	17.	55.	4.
Difference between the two	4.	4.	56.
As the Star's time exceeds the Sun's, Subtract that difference from Sun's R[t] Aſcenſion . . .	10.	38.	58.
Remains the Right Aſcenſion of the Star	6.	34.	2.

Its Declination (by the Nonius of the Declination Circle) is 16°. 25.′ 1.″ South.

OBSERVATION V.

To find the Longitude at Land by the Right Aſcenſion of the Moon.

	H.	′	″
Obſerved the Centre of the Moon on the moveable Wire ſet Vertical, either in or out of the Meridian; Time given by the Equatoreal, or Hour Circle, ſuppoſe	2.	28.	2.
Sun's Apparent Time by the Regulator	6.	0.	0.
Difference between thoſe Times	3.	31.	58.
Add that Difference to the Sun's Right Aſcenſion at 6 Hours (becauſe the Moon's Time is leſs than the Sun's Time, for had it been greater, the difference muſt have been *Subtracted*).	8.	25.	27.
And you have the Moon's Right Aſcenſion at the Place of Obſervation at 6 Hours .	11.	57.	25.

Another Method of making the above Obſervation.

The Centre of the Moon being obſerved in the ſame manner at 6 hours — P. M. as before directed, let the Inſtrument remain in the ſame poſition it was (only altering the Declination) till a known Star comes to the Vertical Wire, which will happen (ſuppoſe) in one hour after, *viz.* at 7 hours — then ſubtract that 1 hour of Difference in time of Tranſits, with the addition of $9''{,}86^{\text{dec.}}$ for the acceleration correſponding to 1 hour, that is, ſubtract $1^{\text{H.}}.\ 0'.\ 9''{,}86^{\text{dec.}}$ from the Æ. of the Star, ſuppoſed to

to be, 12. 57. 35. (H. ′ ″) the remainder is the Moon's Æ. at 6 hours P. M. at the Place of Observation—

	H.	′	″
Stars Æ.	12.	57.	35.
Difference in Sydereal Time * . .	1.	0.	9,86
Moon's Right Ascension at 6 hous P. M. at the Place of Observation . . .	11.	57.	25,14

Then find by the Nautical Almanac at what Time at Greenwich the Moon has the same Right Ascension as that now observed.

	H.	′	″
Moon's Right Ascension at Greenwich at Noon is	11.	43.	20.
D^o^ at Midnight .	12.	10.	36.
Difference in those 12 Hours	0.	27.	16.

	H.	′	″
Moon's Right Ascension at Greenwich at Noon	11.	43.	20.
Moon's Right Ascension at 6. hours at the Place of Observation	11.	57.	25.
Difference between them	0.	14.	5.

Proportion

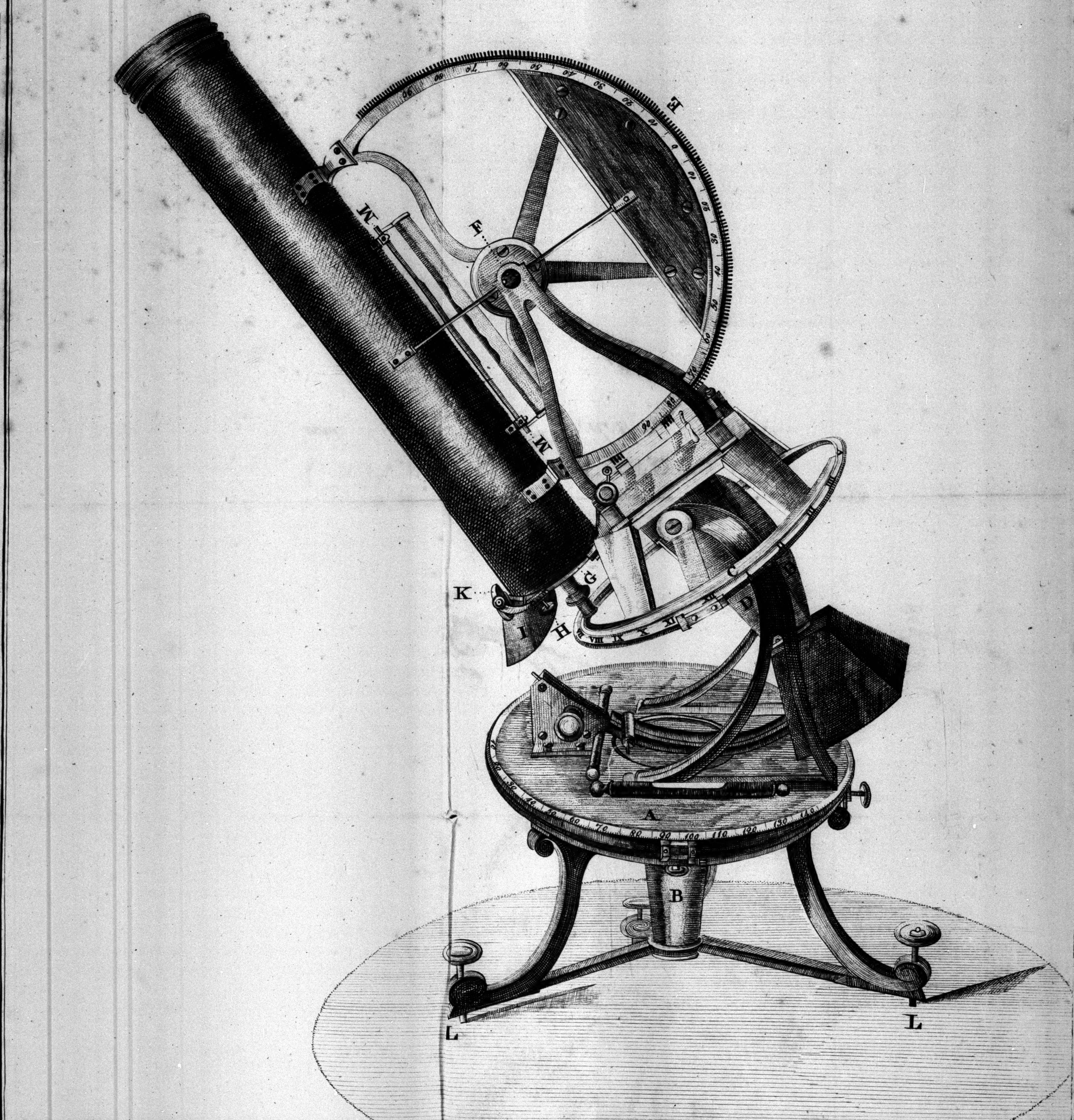
* *N. B. From the acceleration of the fixed Stars, one hour of mean time exceeds one hour of Sydereal time (by which all Right Ascensions of the Heavenly bodies are reckoned) by* 9″, 86 dec. *so that those seconds must be added to each hour of mean time where Sydereal time is required.*

Proportion for finding the Time at Greenwich

$$\text{As } 27'.\ 16'' : 14'.\ 5'' :: 12^{H.} : 6^{H.}\ 12'.\ 0''.$$

So that the Time at Greenwich when the Moon has $11^{H.}\ 57'.\ 25''$. of Right Aſcenſion is $6^{H.}\ 12'.\ 0''$, that is $12'$. later than at the Place of Obſervation, which is therefore $12'$. of Longitude in Time Weſt from Greenwich.

F I N I S.



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made by Mr. J. Ramsden, London

Fig 1.

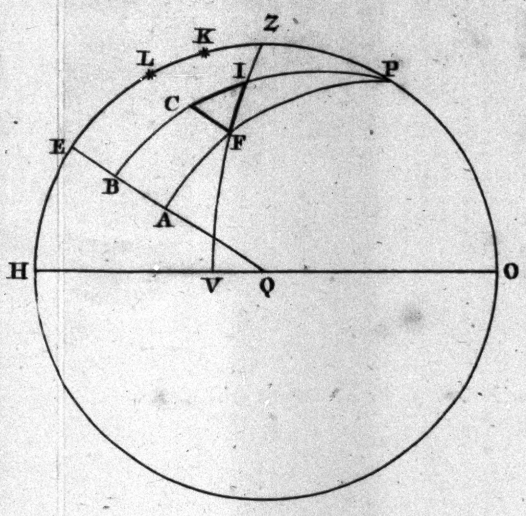

Fig. 3.

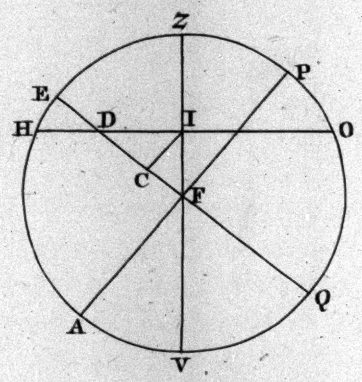

Fig. 2.